SOME EFFECTS OF CONTRAST.

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1. *Kinds of Simultaneous Contrast.* The forms of simultaneous contrast in the domain of sight can be reduced to the following:

1. Contrast in brightness.
2. Contrast in saturation.
3. Contrast in color.
4. Contrast in emotional tone.

The contrast in the size of the surface is omitted as belonging to all the space senses.

These kinds of contrast depend on certain conditions. The strength of the brightness-, color- and saturation-contrasts depends on the intensity of the light emitted from the object; the strength of the color- and saturation-contrasts is dependent on the shade of color and the degree of saturation of the contrasted surfaces; the strength of the contrast is also dependent on the extent of the contrasting surfaces and on the distance of the objects from one another.

The relations of the various kinds of contrast to these variables I have investigated. The results which have been published elsewhere[1] can be summarized as follows:

The intensity of pure simultaneous brightness-contrast, and probably also of the pure simultaneous color-contrast, increases, within the limits of clear perception of size in the resting eye, proportional to the linear extent of the inducing part of the retina, or proportional to the square root of the surface content. An intensity that produces a contrast can be replaced by a less intensity of a correspondingly larger extent without changing the strength of the contrast; that is to say, a relation of reciprocity obtains between the extent and the intensity of the colors that enter into the contrast. The simultaneous color contrast appears best when the brightness-contrast is excluded or reduced to a minimum. The simultaneous contrast between a color impression and a gray of

[1] KIRSCHMANN. *Ueber die quantitativen Verhältnisse des simultanen Helligkeits- und Farben-Contrastes*, Inaug.-Diss., Leipzig, 1890; also in Wundt's Philos. Studien, 1891 VI. 417.

equal brightness increases with the saturation of the inducing color. The simultaneous contrast between two colors is composed of two factors, the quantitative relations of which with a regular increase or decrease of the saturation of the colors change in irregular manner and in opposite directions. The mutual contrast between two colors reaches its maximum with a combination of medium degrees of saturation of the colors.

2. *Black and White.* Among the effects of contrast there is one to which attention has not been called, although a neglect of the influence of contrast has led to a fatal error in Hering's theory of the fundamental colors. As is well known, his theory asserts the production of the various colors by the greater or less preponderance of the associative or the dissociative processes between two opposed pairs of fundamental colors. Likewise black and white are two such fundamental sensations and our different sensations of brightness without color are produced according to the preponderance of the one or the other of the processes in this pair. This assertation that black and white are elementary sensations is unjustified, as I shall attempt to show.

Right here, however, I must call attention to the fact that I do not have anything to say against the sensations of brightness, or the achromatic series of sensations of light, as such; this is, of course, too amply proved to need mention. But I do object to the unproved assumption that this series is produced by two antagonistic sensations just as a simple color is produced. On the other hand I am quite ready to agree to the view that black and white are extremes of a series which is not analogous to a series of simple colors, but to the degrees of saturation of a color; that is, white and black are not the extremes in the same way as red and blue-green are the extremes of the series of colors from red to blue-green, but are extremes in the same way that colorless light and the highest degree of saturation are the extremes of a series of any color in regard to its saturation.

Hering's theory regards colors as lying in two bipolar systems which have a point of indifference. If, e. g., the sensation red corresponds to the condition of assimilation and the sensation of blue-green to the condition of dissimilation of that particular substance, then colorlessness denotes the condition where the activity of the substance is zero. If we apply these relations to the black-white series, then the point of indifference is to be sought in the middle gray; to regard the middle gray as the zero-point of the activity of the black-white substance is a hypothesis that is not to be accepted lightly.

Are white and black really sensations? Hering's theory requires an affirmative answer to this; nevertheless the facts require, as I intend to show, a negative one. A phenomenon is to be considered a sensation, i. e., a simple mental phenomenon, when it cannot be further analyzed. It must maintain its character qualitatively unchanged even when isolated from all other mental elements. For example, the sensation red is not necessarily bound to any other phenomenon of consciousness. We always recognize this particular quality of light as red, no matter what the surrounding conditions may be, provided there is nothing abnormal about our organs of sight. In order to recognize an object as red

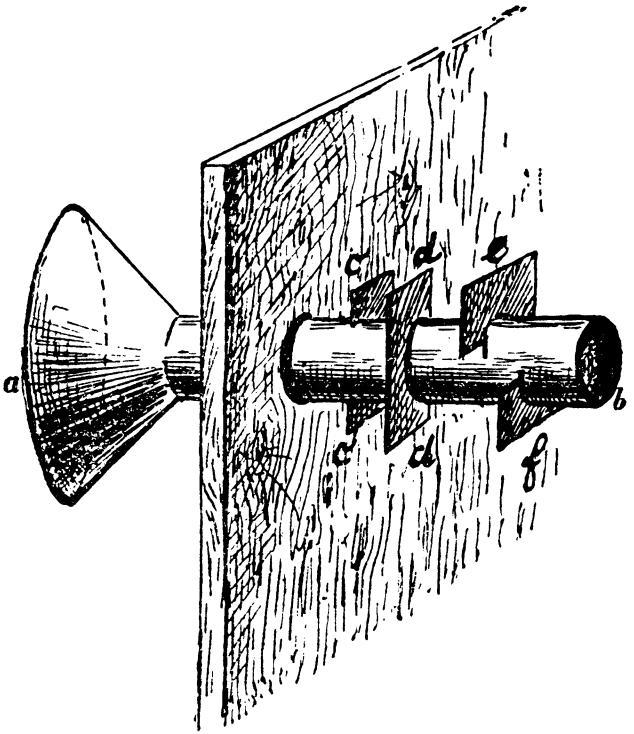

FIG. 6.

nothing more is necessary than that we see it; isolate it from surrounding objects or bring it into any relation to them, it never appears blue or violet, but always red. Surrounding objects, however, do have a great influence on the degree of saturation; the shade of a given red will be different accord-

ing to various influences. Can we say the same of black and white as of red and the other colors? I will first describe some experiments that answer this question, after which a number of familiar illustrations will be given.

The apparatus, which is not difficult of construction, is shown in figure 6. A wide tube *a b* is painted outside and inside with Paris black and is inserted through the door of the dark room so that the wider end is outside while *b* is in perfect darkness. Four diaphragms, *c*, *d*, *e* and *f*, are placed in corresponding slits in the tube in such a way that an eye looking through the tube sees an opening about two cm. square. They are placed at a distance from one another so that even the small quantity of light reflected from the walls of the tube is kept back from the neighborhood of the square opening. When in the dark room various colored or colorless surfaces are brought before the end of the tube, the observer at *a* is able to recognize only the intensity and the quality of the light reflected from the surface as long as the surface is so held that the edge of it cannot be seen within the square. By changing the illumination (lamp-light, gas-light, daylight), by changing the position of the reflecting surface to the direction of incidence of the illuminating rays and finally by the interposition of colored and gray glasses, the quality and intensity of the reflected light can be changed at will without the observer knowing anything more than the actual change on the surface observed. The observer was called upon to name the various lights and colors seen through the opening. A series of so-called blacks, e. g. black cardboards, dull black paper, Paris black, etc., was first presented before the tube so that nothing more than the surface was seen. Dr. Leitzmann, who was kind enough to serve as observer in these experiments, was called upon to name the colors. He did not designate a single one as black, but every one as gray, dark gray, a trifle light, somewhat light, rather light, etc. The term black was used only in the case where the opening was completely closed by the diaphragms. Even the best Paris black and the still blacker shadow that can be cast on it were perceived as light; indeed, by very strong illumination they produced the impression of light gray, and on one occasion, by a sudden change from daylight to gas-light, that of yellow. White papers and cardboards were not recognized as white, but, according to the illumination, as light, light gray, very light, light yellow, etc. With great decrease of the illumination they were gray, dark gray, very dark. Only once was an impression recognized as white, and this was from a piece of dirty gray but strongly illuminated wrapping paper. On the other hand colored papers were always correctly

recognized, provided the saturation was sufficient for the contrast with the black field of vision not to render the color entirely unnoticeable.

This fact, that our blacks and whites are in reality only grays, is seen in many every-day experiences. That we name an object black or white rather than gray does not depend alone on the quality and the intensity of the sensation of light, but essentially on the fulfillment of other conditions that have nothing to do with the sense of sight. Here we find not only the various properties of the object itself, but also two entirely subjective factors. The first of these is the peculiarity of the sense of sight mentioned in a previous treatise,[1] by means of which on the foundation of the intensities in the field of vision we form for ourselves a maximum of brightness that is not to be exceeded in our reproduced ideas until brightnesses of greater strength enter the field of vision. On a dull autumn day let the eye be fixed on a sheet of white paper and try to imagine fresh fallen snow in a degree of brightness exceeding that of the paper; it will be difficult or impossible, because the memory of the snow is too weak to compete with perception. The case is different when in winter we come directly from the snow-covered street into the room and make the experiment, because what is said of the brightnesses in the field of vision of course holds good also for the very lively memories of strong impressions which have just disappeared. Exactly the same can be shown of the saturation of the colors. Upon looking at a sheet of the best quality of red Heidelberg paper we cannot succeed in imagining a still finer, more saturated red, although the pigment does not produce the highest degree of possible purity and saturation. Of this we can easily convince ourselves, if we compare it with spectral red or even only with red glass by transmitted light or with the best silk velvet. This relativity of the maxima of brightness and saturation—which is to be regarded as a necessary result of the general law of relation—is only one reason why we are inclined to call brightest and most colorless objects in the field of vision by the name "white" and the darkest and most colorless objects by the name "black."

The second of the above mentioned factors is the ever-ruling inclination to correct the present sense-perceptions by connection with previous contents of consciousness, i. e. out of the present impressions and the memories of previous impressions called forth by the given object or those like it we form a complex of sensations or percepts, which necessitates

[1] KIRSCHMANN, *Ueber die Helligkeitsempfindung im indirecten Sehen*, Philos. Studien, 1889 V. 481.

us, on account of the constancy needful for a later recognition, to abstract from some of the components or at least to give them a less degree of attention. We recognize the domestic cat in every illumination, although the visual presentation can differ to an extreme degree in regard to intensity. We pay no essential attention to the illumination, although the presentation was only possible through it. In other words, we represent to ourselves the things not as we see them at the moment, but as we know that they are. When we ask a four to six year old child to draw a face on the slate, it very often happens that a profile with two eyes is produced. The explanation seems to show the same tendency as that just mentioned. The child has often enough seen human beings in profile, but the eye is the most important part of the face and he cannot represent a human being to himself without the two eyes, and he thus corrects his presentation of faces in profile by the adding the other eye. This is exactly the same as the case of every student of drawing. Errors in perspective are constantly made because the person draws things as they are and not as he sees them. An amateur, for example, in painting a winter landscape will hesitate to picture the deep shadows on the snow and he will draw the snow perfectly white, as he thinks it to be.

Black, according to Wundt, is the sensation from the complete inactivity of the retina, but it never occurs in one with normal eyes, since special retinal light is never absent. In external objects the nearest possible approach to black is an extremely dark blue. The best Chinese ink, which appears as the deepest black when drawn as a line on white paper, is readily seen to be a gray when it is used to cover a large surface. Even Paris black, which is the blackest of all pigment, is not a full black, for on a surface covered with this black we can draw still blacker lines with the same pigment. Compared with the inner surface of a black cylinder, the Paris black appears distinctly gray. It is just the same with writing-ink or printer's ink; it appears black to us only so long as it is in small lines or letters or numbers on a bright background, where the simultaneous and the border contrasts are so weakened that the difference between the characters in pigment and the retinal light is not perceived. In short, every case where we believe ourselves to see complete absence of light is due to contrast in brightness.

We designate those surfaces as white, concerning which we have learned by experience that with every illumination they possess the maximum capability of reflection and colorlessness. The swan is white, even when it is in the deepest shadow. Even the shadow on the feathers of the swan no one would

call gray, although they are far darker than the lights. A piece of white paper can be held at such an angle to the incident light that it is really not so light as a piece of gray paper beside it, which has a better illumination, and no one would call the former gray; yet we believe that we see the former as white and the latter as gray. This, however, happens only as long as we know what the shades of the two really are. If we do not know this, then we judge the two as we actually see them, just as in the experiment described above.

From these considerations it seems to me clear that in order to attribute to an object the property "black" or "white," we need to know more than the quality and intensity of the illumination of the objects and that these designations are not designations of sensations, but of judgments. Black and white are thus concepts and not sensations. There are white objects, but no sensation white, what we call white being simply a gray, with a surface that possesses the maximum degree of capability of reflection under the various conditions of illumination.

3. *Effect of Colored Illumination.* It is often said that in the evening by lamp-light the yellow objects appear almost white and are scarcely to be distinguished from white. This, however, is an illusion of the judgment; just the reverse is true. In reality the white objects appear yellow and the yellow objects still more yellow in the light of the lamp which is rich in red and yellow rays, but lacking in a corresponding quantity of blue rays. This is clearly seen when a piece of white cardboard is so arranged that half of it is illuminated by daylight and the other half by lamp-light, with the appropriate protection from extraneous light. The half lighted by the lamp appears decidedly yellow or pale orange, and yet in the evening under the same illumination, when we have nothing really white with which to compare it, we call it white.

Just the same thing happens in looking through weakly colored glasses or sheets of gelatine. We believe ourselves to see the objects in their proper colors, as though we could see one color through another. This supposition is incorrect, as is seen by looking at colored surfaces through the apparatus mentioned above in such a manner that neither the edges of the objects nor the character of their surfaces is seen. The mixed color produced by the color of the object and that of the glasses will then be seen and the illusion will disappear. The knowledge of their true colors which we have from general experience has led us to believe that we see the objects in their usual colors in spite of the influence of the glasses.

This explanation, however, is sufficient only in the case of slightly colored glasses. With glasses of more saturated colors there are also two additional factors that show themselves, the fatigue of the retina and the purely psychological influence which assists the recognition of the colors of the objects and an abstraction from the color of the glasses.

With a pair of spectacles, specially made by Krille in Leipzig, in which various colored glasses could be set and which were provided with side screens to keep out extraneous light, I was able to perform in a convenient way all the experiments described by Fechner in his essay on contrast.[1] My results do not differ essentially from his. When the spectacles are provided with blue, violet, yellow or green glasses, after a short time the impression of color disappears and the objects appear in their natural colors with the exception of those objects whose colors are extinguished by the glasses. Black and white objects appear black and white in spite of the fact that only colored light reached the retina from them. The color of the glasses is noticed only in looking at very bright objects.

The color disappears still more quickly when two different glasses are used, e. g. blue for the right eye, purple for the left, or yellow for the right, violet for the left, at the same time taking care that the colors are of about the same degrees of brightness in order that the disturbing rivalry of the two fields of vision may be avoided. In such cases the illusion from the judgment goes so far that the objects are supposed to be in their proper colors and it is generally impossible to say before which eye the blue, before which the purple, glass is.

The fatigue of the retina is not the only cause of this phenomenon, for the illusion occurs almost immediately and the posterior images that always follow fatigue are either very weak or entirely lacking. Moreover, the fact that we do not judge objects according to their intensity and the qualities of their lights is also not sufficient to explain the phenomenon. There seems to be another influence of purely psychological character, arising from the relation in which the sensations of color stand to one another and being a direct result of the general law of relativity. Here we have to do with a lack in the relation of the color of the glass to other colors. If we hold a blue glass before the eyes, it is only in the first moments that we have any occasion to compare the illumination of the objects seen through it with the normal illumination.

[1] FECHNER, *Ueber die Contrastempfindung*, Ber. d. Kgl. sächs. Ges. d. Wiss., math.-phys. Cl., 1860, 71.

The longer the new illumination continues, the fainter the relation to previous illumination becomes, while there is no possibility of a comparison with the usual illumination at the same time, since with use of the completely protected spectacles just described the colored illumination covers the whole field of vision.

In these experiments I made the same curious observation as Fechner, namely, that the red glasses were an exception in so far that the impression of the dominating color disappeared much more slowly and in the case of bright objects never dis-

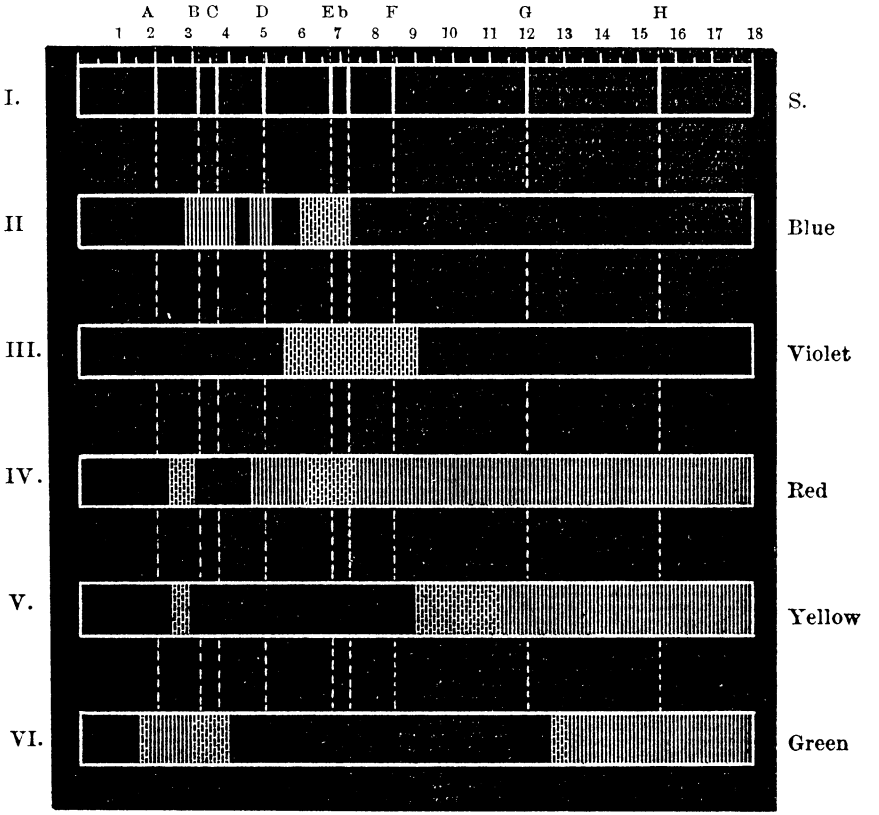

FIG. 7.

appeared entirely. Nevertheless I do not think that any higher or more enduring sensitiveness for red is present; on the contrary, I believe that the peculiarity has its cause in the physical character of the glasses. A transparent body can

possess a color from two entirely different reasons; either when it allows only rays of a certain wave-length to pass through, or when it allows all to pass through except those of the complementary color. A glass can be yellow because it allows only yellow's rays to pass or because all rays pass through it with the exception of the blue rays which it absorbs. The glasses which I used in the experiments just described were examined with the spectroscope. The results are shown in figure 7, where I. indicates the solar spectrum with some of the principal lines, and the others the spectra of various glasses, the color as it appears to the eye being written beside it. Those parts of the spectrum which were completely blotted out are shaded with parallel lines, while those that appeared faintly are represented by crossed lines. It is very clearly seen that the glasses that gave the spectra II., III., V. and VI. (blue, violet, yellow and green) owe their colors as seen by the eye to the fact that the complementary color is eliminated, while the remaining colors are allowed to pass, although some of them are weak. The red glass, however, (superficial oxide of copper coloring) has its spectrum cut off sharp before the D line and with the exception of a light gray glimmer in the place of green permits only light from $\lambda = 0.0007258$ to $\lambda = 0.0006026$ to pass. In consequence of this its effect on the eye is quite different from that of the other glasses. The others do not weaken the light from the objects to any great degree, with the exception of those in the complementary color, and consequently their relative relations of brightness remain almost undisturbed, so that we easily recognize the colors and shades. On the other hand the red glass causes the greatest disturbance in the relations of intensity of the colors of the objects. All red objects appear bright, while all those otherwise colored are seen to be much darker, often almost black. This difference is made still greater by the contrast in saturation between these two classes. Both these influences render it difficult or impossible to abstract from the red coloring and to judge objects in their usual colors, as is done with the other glasses.[1]

[1] This explanation could be tested by use of spectacles fitted with blue, green, yellow, etc., combinations of gelatine sheets prepared in the manner described by Kirschmann, *Ueber die Herstellung monochromatischen Lichtes*, Philos. Studien, 1891 VI. 543, and so arranged that these colors are pure spectral colors like the red. The result ought to show that such colors have the same effect as the red. On the other hand red plates produced by the absorption of the complementary color ought to act as the blue ones described in the text.

E. W. S.

4. *The Idea of Polish.* Contrast has also a large influence in the idea of luster or polish. I say "the idea of polish," for the polish is not directly given as sensation, but is a product of the combination of sensations.[1] According to Wundt, polish is to be regarded as an incomplete mirroring, whereby under mirroring we understand the regular reflection of light from a plane or a curved surface. Polish rests upon the reflection of the light, which, although not complete like the reflection from a mirror, (where instead of the mirror we see only the object mirrored) nevertheless is not so irregular as the usual dull surfaces. With dull surfaces the light which comes from any direction is strongly reflected in all directions, while in a mirror only one direction of the reflected rays corresponds to each direction of incidence. Between these two extremes there lies the whole series of possibilities where light is reflected in all directions, but one direction is particularly favored; these belong to the category of luster or polish. The favored direction in which the light is reflected depends on the physical conditions, on the number, the position and the size of the sources of illumination, on the form of the shining surface, but is completely independent of the eye. Therefore with even the smallest movements of the eye we see displacements of the relations of intensity. Just this fact is for us the criterion of polish. Likewise the binocular observation of the object enables us to judge of luster, since the two retinal images have their maximum intensities in different places.[2] To this we must add, in the case of bodies of a luster approaching mirroring, the influence of the doubtful fixation of the visual axes and of accommodation.

Nevertheless even in cases where these conditions are not fulfilled, where every influence of the mutual support or rivalry of the fields of vision or the movements of the eyes is removed by monocular observation with completely unmoved eye, and where the object is so far distant that the insecurity of the accommodation and convergence of the visual axes can no longer come in question, the polish is in many cases still present. The explanation of these cases has therefore to be sought in something else than the influences mentioned.

In such cases we recognize objects as polished that send out a not completely diffused light when under a single illumination; the brightness of various parts of the surface stand in such a relation as, according to our experience, cannot come from an irregularly reflecting surface. It is here a

[1] WUNDT, *Beiträge zur Theorie der Sinneswahrnemung*, 315, Leipzig and Heidelberg, 1862.

[2] On the relations of between binocular contrast and polish, see WUNDT, Phys. Psy. II. 179, Leipzig, 1887.

question of considerable differences of brightness between adjacent places of the surface; this is a matter which can be essentially influenced by contrast, especially when we are unacquainted with the source of illumination.

Bodies that completely disperse the light show no differences of intensity on approximately even surfaces with a single illumination and only moderate variations on curved surfaces; the passage from light to shadow follows in a manner completely dependent on the form of the surface. As soon, however, as we perceive greater differences of brightness on a surface of a single object than would be possible with a diffuse reflecting surface, we say that the object has polish. These differences of intensity according to the prevailing maxima of brightness are produceable not only by direct differences of intensity but also under favorable circumstances by contrast; thus in monocular perception of polish we are exposed to many illusions. For example, a gray ball of dull surface can be so painted with black and white pigments that by monocular observation and unmoving eye, it cannot be distinguished from a polished, unpainted, gray ball. Movement of the eyes or binocular observation, of course, destroys the illusion. This in the weapon which in the hands of a painter enables such startling representations of polished objects by means of pigments.[1]

5. *The Emotional Tone in Contrast.* The part played by the emotions in relations of contrast is scarce less than the usual qualitative and quantitative properties of the sensations. Lipps, indeed, regards this factor as the only psychological contrast, others being physiological.[2] Nevertheless it is easily seen that the contrast between the emotions accompanying the sensations, besides the actual emotional contrasts of the sensations, being to a certain degree dependent on it without the intensity and quality contrast being bound to it with like necessity. The sensations of light can be so chosen that they are totally indifferent in regard to their emotional tone, although they are otherwise totally unlike; on the other hand an emotional contrast separated from every contrast of brightness and quality is inconceivable.

The emotional contrast, however, although at present not accessible to quantitative measurement, determines the æsthetic effect of the colors and their combinations as a result of the simultaneous contrast of the sensations. The difficulties of establishing fixed rules for this action of the

[1] See also KIRSCHMANN, *Die psychologisch-ästhetische Bedeutung des Licht- und Farbencontrastes*, Philos. Studien, 1891 VII 362.

[2] Grundthatsachen des Seelenlebens, 273.

emotional contrast rests chiefly on the fact that all the kinds of contrast, those of brightness, of saturation, of color and of the emotional tone, each of which is itself variable, can take part in the result, all of which influences must be taken into account. It is a fatal error to judge the æsthetic effect of a combination of colors from the standpoint of the color-contrast alone. It is an absurdity to make such a statement as, "green and blue do not go well together;" it should be, "a certain green and a certain blue when combined in certain degrees of brightness and saturation make a disagreeeble impression." The color-contrast between green and blue is small, but it can be replaced by one or both the other two kinds of contrast; an example in point is the beautiful contrast between the weakly saturated and intense blue of the sky with the highly saturated dark green of the forests or with the yellowish green of the fields. The reverse of the usual statement can be made, namely, that the contrast between any two colors can produce an agreeable effect, provided the contrasts of brightness and of saturation are properly chosen. The maximum emotional effect is reached when all the three—color, brightness and saturation—are properly contrasted.

6. *Preventive Effects.* Although attention is generally turned to the strengthening effects of contrast, it is nevertheless true that the case often occurs where contrast hinders us from detecting a difference between two qualities or intensities of light. Such a case of the hindering effects of contrast is found in the fact observed by Arago and Hankel,[1] that two unlike but not very different intensities are more easily judged on a moderately bright background than on a darker one. The cause of this is not, as Fechner thought, the "reversed" contrast (the so-called light-induction), but is simply the brightness-contrast. The two small objects (in the Hankel-Fechner example two small slits) are so much raised in their brightness that they come very near the maximum of brightness, whereby their very small difference disappears.

An exactly similar experiment can be made as follows: India ink has a brightness of $\frac{1}{2\frac{1}{3}}$ that of a certain white paper; lampblack has a brightness of $\frac{1}{66}$ compared with the same paper. That is, the former reflects nearly three times as much light as the latter, as can be seen at the first view when the two colors are spread beside each other in large surfaces. Nevertheless if we draw two thin lines on white paper, one with India ink, the other with lampblack, we find that they

[1] FECHNER, *Ueber die Contrastempfindung*, Ber. d. Kgl. sächs. Ges. d. Wiss., math. phys. Cl. 1860, 90.

show no difference, the contrast in brightness with the white paper having reduced them both nearly to the minimum of brightness.

Another effect of contrast is the so-called light-induction. This is, however, not to be regarded, like the usual cases of contrast, as a constantly occurring factor of every perception of sight, but as an exceptional case which occurs only after long fixation. This phenomenon has up to the present been investigated only as the accompaniment of successive and contour contrast. In these cases it is probably to be explained physiologically, as brought about perhaps by the phenomena of fatigue and subjective changes occasioned by the exertion of the organs of fixation (movement) and accommodation or by the interocular changes of pressure, or perhaps by the extension of the stimulation to neighboring parts of the retina. Whether such phenomena of light-induction occur as results of simultaneous contrast is a question that has not been answered.

There is, however, a phenomenon that at first sight might seem to be a light-induction, but is really to be explained otherwise. When we steadily fixate a bright object on a dark background it gradually loses its brightness, while the background becomes lighter. This is a necessary result of simultaneous contrast and we do not need to introduce a new property of the organ of vision. The dark background in the neighborhood of the bright object is really so dark only by contrast with the object. Even a moderately bright object illuminates not only the corresponding portion of the retina on which its image is projected, but also all the rest of the retina on account of the reflection from the retinal image, on account of the very imperfect refraction of the lens-system, and finally on account of the very imperfect opacity of the eyelids and the portions of the sclerotica and chorioidea around the pupil. Even with closed eyes remarkable quantities of light penetrate through the lids to the retina; with open eyes the amount spread over the retina must be very much greater. This brightness of the whole retina generally escapes our notice on account of the contrast with the direct illuminated portions. By long continued fixation of a bright object, however, there occurs a progressive fatigue which, on account of the impossibility of a comparison with other objects not under the same conditions, we are aware of only through the change in the relation of the intensities of the object and the background. But the more the actual intensity of the bright retinal picture decreases the less becomes the effect of the contrast on the dark background. This consequently appears to become lighter, since its illumination, derived in the ways

mentioned above, takes a more prominent part when not repressed by contrast. Exactly analogous is the case of a colored object on a dark background.

That contrast is able under certain circumstances to repress the otherwise perfectly apparent difference, is seen in the following experiment. Let a small circle be painted with a very thin solution of carmine or ultramarine; it will be of a dull pink or a bright blue color and will be quite distinct from the white background. Now, with the same color but in such saturation that it covers the white thoroughly, paint around it a ring of a thickness equal to the diameter of the circle; the circle will appear to be as perfectly white as the background. In this experiment we have to do with a simultaneous contrast in saturation and brightness; the former brings it about that we do not perceive the color of the inner circle and the latter prevents the inner circle from appearing darker than the external background. That the brightness-contrast exercises a stronger effect on the inner circle than on the external background is partly the result of the fact that the background is nearer the maximum of brightness and can be made brighter only to a small degree; it also depends on the relation of the strength of contrast and the extent of the contrasting objects.

7. *Recognition of Objects.* It is a matter of great importance to determine if the general psychological law, that we judge impressions not according to their absolute values, but according to their relations to one another, works favorably for the accomplishment of the functions of the sense of sight or not.

The duty of our sense of sight lies evidently not in perceiving absolute intensities and qualities of light, but in recognizing and naming familiar objects under the most varied circumstances, and in giving unfamiliar objects their proper positions among the familiar ones. For these purposes the brightness and the color of bodies are the most important, since we can recognize their outlines and size only by help of quantitative and qualitative variations of light.

This is readily shown by an example from common life. Suppose, when we look into a room on different occasions, we see it under continually different degrees of illumination. Every object reflects a different amount of light on each occasion. Yet this in no way affects our recognition of them. We recognize them under the most varied conditions. For recognizing them we make use of their outlines and their *relative* intensities of illumination.

The absolute intensities and colors of objects, the surfaces

of which, according to their physical characters, always reflect only a small percentage of the light falling upon them, are exceedingly untrustworthy factors of the visual percepts, on account of the extremely frequent and extensive change of illumination, and are therefore the worst means imaginable for the recognition of objects. In case, however, sensations of brightness and color are to assist in the recognition and determination of objects by means of their degrees of intensity, then the eye can measure not according to absolute but only according to relative standards, since the relation between the brightness and color of an object and that of its surroundings remains the same within considerably extended limits on account of the almost complete constancy of the co-efficients of reflection, which are valid for the kinds of light possible in common life.

If we were to estimate according to absolute intensities, the sensations of brightness would be of value for the recognition of objects only in so far as they provided an easy perception of the outlines of the objects and their parts. Every variation of illumination, however, would change essentially not only the whole picture of the objects in the field of vision but would also disturb and distort the relations of brightness of these objects to one another up to the last degree of indiscernibleness.

Since we are, on the contrary, under the greatest possible abstraction from or removal of the recognition of absolute differences, and are provided with the ability to recognize and to estimate not intensities themselves but their relations to one another, therefore we are placed in a position to recognize objects through the relations of brightness of their surfaces in as far as the co-efficients of reflection remain constant by variable illumination.

It is to the law of relation that we owe the possibility of carrying out this chief function of the sense of sight, namely, the recognition and the determination of the objects of the external world. Indeed, we can say "contrast" in place of "law of relation;" for contrast is merely the expression of our conviction that the same intensities of the stimuli possess different worths as sensations according as they enter into various relations to other impressions; or, in other words, that the difference of two sensations cannot in all cases be referred to the difference of the stimuli which cause them, and that therefore from the likeness or unlikeness of sensations and ideas we cannot judge the likeness or unlikeness of the objects unless we take the whole contents of consciousness into consideration.